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Docket No.: M4065.0248/P248-C
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Allen McTeer

Application No.: 10/656,182

Confirmation No.: 8422

Filed: September 8, 2003

Art Unit: 2815

For: A MULTI-LAYERED COPPER BOND PAD
FOR AN INTEGRATED CIRCUIT

Examiner: E. Lee

RESPONSE TO NOTIFICATION OF NON-COMPLIANT APPEAL BRIEF

MS Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

In response to the Notification of Non-Complaint Appeal Brief mailed May 25, 2007, Appellant hereby submits the attached Amended Appeal Brief. The Amended Appeal Brief amends the names of Appendices A, B and C to "Claims Appendix," "Evidence Appendix" and "Related Proceedings Appendix," respectively. Appellant submits that the attached Amended Appeal Brief is in compliance with 37 CFR 41.37(c).

Dated: June 11, 2007

Respectfully submitted,

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AN INTEGRATED CIRCUIT

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AMENDED APPEAL BRIEF

MS Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

As required under § 41.37(a), this brief is filed within two months of the Notice of Appeal filed in this case on February 2, 2007, and is in furtherance of said Notice of Appeal.

The fees required under § 41.20(b)(2) are dealt with in the accompanying TRANSMITTAL OF APPEAL BRIEF.

This brief contains items under the following headings as required by 37 C.F.R. § 41.37 and M.P.E.P. § 1206:

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|-------|---|
| I. | Real Party In Interest |
| II | Related Appeals and Interferences |
| III. | Status of Claims |
| IV. | Status of Amendments |
| V. | Summary of Claimed Subject Matter |
| VI. | Grounds of Rejection to be Reviewed on Appeal |
| VII. | Argument |
| VIII. | Conclusion |
| IX. | Claims |

Appendix A Claims
Appendix B Evidence
Appendix C Related Proceedings

I. REAL PARTY IN INTEREST

The real party in interest for this appeal is:

MICRON TECHNOLOGY, INC., a corporation organized under and pursuant to the laws of the United States, and the assignee of this application.

II. RELATED APPEALS, INTERFERENCES, AND JUDICIAL PROCEEDINGS

There are no other appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

III. STATUS OF CLAIMS

A. TOTAL NUMBER OF CLAIMS IN APPLICATION

There are 9 claims pending in application.

B. CURRENT STATUS OF CLAIMS

1. Claims canceled: 1-73 and 81
2. Claims withdrawn from consideration but not canceled: None
3. Claims pending: 74-80, 82 and 83
4. Claims allowed: None
5. Claims rejected: 74-80, 82 and 83

C. CLAIMS ON APPEAL

The claims on appeal are claims 74-80, 82 and 83.

IV. STATUS OF AMENDMENTS

Appellant filed a response to the Final Rejection on January 3, 2007, which did not contain any proposed claim amendments. There have been no claim amendments since the final rejection was mailed and all previous amendments have been entered.

The claims enclosed herein in Appendix A incorporate the amendments indicated in the paper filed by Appellant on August 21, 2006.

V. SUMMARY OF CLAIMED SUBJECT MATTER

The claimed invention relates to a multi layered copper bond pad 39 for a semiconductor die 10 (shown in FIGS. 1 and 3 of the present application) which inhibits formation of copper oxide. Specification, page 4, line 23 – page 5, line 1. The copper bond pad 39 is shown, for example, in FIG. 7 or 12, reproduced below for convenience.

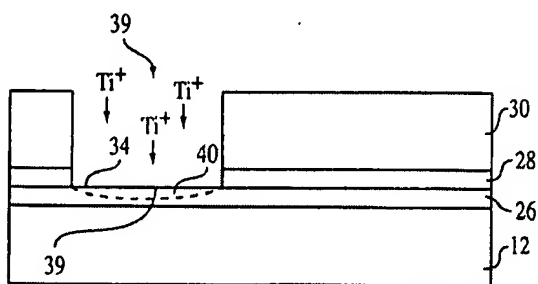


FIG. 7

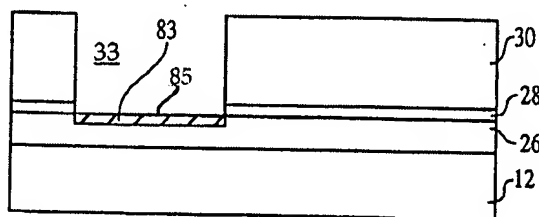


FIG. 12

In the embodiment of FIG. 7, a small dose of titanium 40 is implanted at the surface 34 of the copper layer 26. Specification, page 11, line 20 – page 12, line 6. In the embodiment of FIG. 12, a titanium-aluminum-copper-nitrogen alloy layer 83 is formed from the copper layer 26. Specification, page 13, line 18 – page 14, line 2. The implanted titanium layer 40 (or the titanium-aluminum-copper-nitrogen layer 83) suppresses the growth of copper oxide in the copper layer 26 of the bond pad 39 by controlling the concentration of vacancies available to copper ion transport.

Abstract.

An interconnect structure 50 (shown in FIGS. 3 and 4 of the present application), such as a wire bond or a solder ball, may be attached to the copper bond pad 39 to connect the semiconductor die 10 to a lead frame or circuit support structure. Specification, page 9, lines 11 – 19. Using the claimed bond pad 39 reduces the amount of copper oxide that may form on copper layer 26; reduction of formation of copper oxide is desirable because oxidation may reduce the conductivity of the bond pad 39. Specification, page 4, lines 16 – 20.

Independent claim 74 recites a copper bond pad 39 for a semiconductor device 14. The bond pad 39 includes a dielectric layer 22 formed over a substrate 20 of the semiconductor device 14, a barrier layer 24 formed over the dielectric layer 22, a copper layer 26 formed over the barrier layer 24, and an insulating layer 28 over the copper layer 26. Specification, page 8, line 20 – page 9, line 2; page 9, line 25 – page 10, line 13. The copper layer 26 has titanium 40 implanted within and near only an upper surface 34 of the copper layer 26. Specification, page 11, line 20 – page 12, line 6. Further, the copper layer 26 is primarily copper and has a thickness of about 500 Angstroms to about 20,000 Angstroms. Specification, page 10, lines 14 – 19. Additionally, the implanted titanium 40 reduces the formation of copper oxide on the copper layer 26. Specification, page 4, lines 16 – 20. The substrate 20, dielectric layer 22 and barrier layer 24 are shown in FIG. 5 of the present application and make-up substrate 12 shown in FIGS. 7 and 12. Specification, page 9, line 25 – page 10, line 13.

Independent claim 79 recites an interconnect structure 50 for a semiconductor die 10. The interconnect structure 50 includes a conductive bond pad 39 containing a copper layer 26 further containing a copper oxide layer 85 thereon. Specification, page 13, line 18 – page 14, line 2, as amended February 23, 2006. The interconnect structure 50 further includes a titanium-aluminum-copper-nitrogen layer 83 formed as part of the copper layer 26 and from a portion of at least an upper surface of said copper layer 26. Id.

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

A. The rejection of claims 74 and 75 under 35 U.S.C. 103(a) as being unpatentable over Okada (U.S. Patent No. 6,424,036) (“Okada”) (attached as Exhibit 1 in Appendix B) in view of Tsai et al. (U.S. Patent No. 6,479,389) (“Tsai”) (attached as Exhibit 2 in Appendix B).

B. The rejection of claims 76-78 under 35 U.S.C. 103(a) as being unpatentable over Okada and Tsai and further in view of Hsu et al. (U.S. Patent No. 5,661,082) (“Hsu”) (attached as Exhibit 3 in Appendix B).

C. The rejection of claims 79, 80, 82 and 83 under 35 U.S.C. 103(a) as being unpatentable over Edelstein et al (U.S. Patent No. 6,457,234) (“Edelstein”) (attached as Exhibit 4 in Appendix B) in view of Harada et al. (U.S. Patent No. 5,565,378) (“Harada”) (attached as Exhibit 5 in Appendix B) in view of Mahulikar et al. (U.S. Patent No. 5,320,689) (“Mahulikar”) (attached as Exhibit 6 in Appendix B).

VII. ARGUMENT

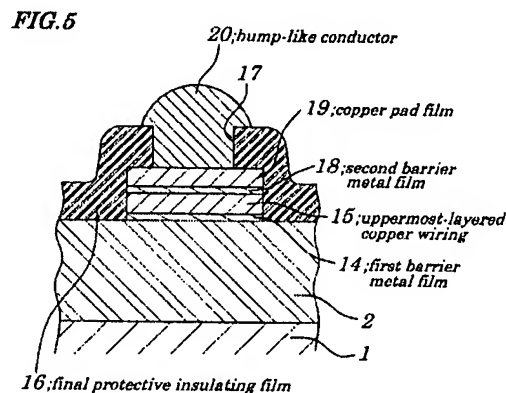
A. CLAIMS 74 AND 75 ARE PATENTABLE OVER OKADA IN VIEW OF TSAI

1. Claim 74 is not obvious in view of Okada and Tsai.

Claim 74 recites a copper bond pad for a semiconductor device including a “dielectric layer,” a “barrier layer,” a “copper layer having titanium implanted within and near only an upper surface of [the] copper layer, [the] copper layer being primarily copper and having a thickness of about 500 Angstroms to about 20,000 Angstroms,” and an “insulating layer over [the] copper layer.” Further, the “implanted titanium acts to reduce formation of copper oxide on [the] copper layer.”

The claimed invention relates to a multi-layered copper bond pad on which the formation of copper oxide is inhibited by implanting titanium into the upper surface of the copper layer. Specification, pg. 4, line 23 – page 5, line 4. The implanted titanium suppresses the copper oxide growth by controlling the concentration of vacancies available to the copper ion transport. Abstract; Specification, page 12, lines 7 – 20.

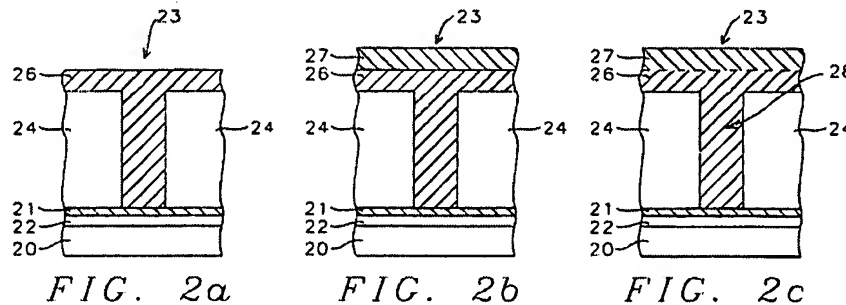
Okada relates to a method of forming semiconductor devices including barrier metal films between an insulating film and the copper layer and between copper layers. Okada, Abstract; FIG. 5 (reproduced below). As admitted by the Examiner, Okada does not disclose titanium implanted in the copper layer, let alone within and near only an upper surface of the copper layer. November 3, 2006 Final Rejection, page 2. Okada merely discloses a semiconductor device with a bond pad metal film.



Okada, FIG. 5

The Examiner relies on Tsai to disclose the implanted titanium. November 3, 2006 Final Rejection, page 2. Tsai relates to a method of forming special copper alloy films which may be used to fill high aspect ratio vias and trenches. Tsai, Abstract. The method first deposits a layer of pure copper within a trench and then a copper alloy film over the copper, either by PVD or sputtering. Id. The copper-titanium layer is formed on top of the copper layer. Tsai, col. 5, lines 43 – 48. Then, in

an annealing step, copper alloy 28 is formed throughout the copper layer 20 (filling the trench) with the copper alloy layer 27 acting as a diffusion source. Tsai, col. 5, lines 59 – 65; FIG. 2 (reproduced below).



Tsai, FIG. 2

- a. The combination of Okada and Tsai does not disclose teach or suggest all of the limitations of claim 74.

To establish *prima facie* obviousness of a claimed invention, all of the claim limitations must be taught or suggested by the prior art. MPEP §2143.03 (citing *In re Royka*, 490 F.2d 981, 180 USPQ 580 (CCPA 1974)). The prior art references cited by the Final Rejection, when considered alone or in combination, do not teach or suggest all the limitations of the claimed invention. Specifically, the cited combination does not disclose, teach or suggest a “copper layer having titanium implanted within and near only an upper surface of said copper layer,” as claimed in claim 74.

Assuming Okada and Tsai are combinable, which Appellant does not concede, the resulting structure would not be that of the claimed titanium layer implanted within and near only an upper surface of the copper layer. Rather, the combination of references would only provide either a copper alloy layer formed merely on a top surface of the copper layer (e.g., Tsai, FIG. 2B) or a copper alloy formed throughout the entire depth of the copper layer (e.g., Tsai, FIG. 2C; col. 5, lines 59 – 64).

The claimed invention, on the other hand, requires the “implanted titanium” to be “within and near only an upper surface of said copper layer,” as shown, for example in FIG. 7, reproduced above. See also, Specification, page 11, line 20 – page 12, line 6. Additionally, the implanted titanium of the claimed invention “acts to reduce formation of copper oxide on said copper layer.” It is important that the implanted titanium be only near an upper surface (e.g., thickness of less than 1000A, and more preferably 50A to 100A) so that the side effects of the implantation are minimal. Specification, page 11, line 20 – page 12, line 6. These important claim limitations are not disclosed in or suggested by the combination of Okada and Tsai.

In light of the above arguments, Appellant respectfully submits that the independent claim 74 is not obvious in view of Okada and Tsai and the 35 U.S.C. § 103(a) rejection should be overturned.

2. Claim 75 is not obvious in view of Okada and Tsai.

- a. Claim 75 depends from claim 74 and is thus allowable along with claim 74.

Dependent claim 75 contains all of the limitations of independent claim 74 and is allowable along with claim 74, for at least all of the reasons discussed above.

- b. Claim 75 is not obvious in view of Okada and Tsai for additional reasons.

As admitted by the Examiner, the cited combination does not disclose titanium implanted with a thickness of about 50 Angstroms to about 200 Angstroms. November 3, 2006 Final Rejection, page 2. The Examiner asserts that the thickness is a result effective variable. Id. However, Appellant respectfully submits that because Tsai teaches the titanium diffusing through the entire copper layer (to fill the trench with copper-titanium alloy) it cannot suggest the titanium diffusing any less than completely through the copper. Therefore, the thickness of the titanium alloy in Tsai would not be a result effective variable.

In light of the above arguments, Appellant respectfully submits that dependent claim 75 is not obvious in view of Okada and Tsai and the 35 U.S.C. § 103(a) rejection should be overturned.

B. CLAIMS 76-78 ARE PATENTABLE OVER OKADA AND TSAI IN VIEW OF HSU

1. Claims 76-78 depend from claim 74 and are allowable along with claim 74.

Dependent claims 76-78 contain all of the limitations of independent claim 74 and are allowable along with claim 74, for at least all of the reasons discussed above.

Hsu is relied upon as teaching a passivation layer, a via formed in the passivation layer, and possible materials for forming the dielectric layer. November 3, 2006 Final Rejection, page 3. Appellant respectfully submits, however, that Hsu does not remedy the deficiencies of the Okada and Tsai combination. That is, Hsu also fails to teach or suggest a “copper layer having titanium implanted within and near only an upper surface of said copper layer, said copper layer being primarily copper and having a thickness of about 500 Angstroms to about 20,000 Angstroms . . . wherein said implanted titanium acts to reduce formation of copper oxide on said copper layer.”

In light of the above arguments, Appellant respectfully submits that dependent claims 76-78 are not obvious in view of the Okada, Tsai and Hsu combination and the 35 U.S.C. § 103(a) rejection should be overturned.

C. CLAIMS 79, 80, 82 AND 83 ARE PATENTABLE OVER EDELSTEIN IN VIEW OF HARADA IN VIEW OF MAHULIKAR.

1. Claim 79 is not obvious in view of Edelstein, Harada and Mahulikar.

Claim 79 recites an interconnect structure for a semiconductor die including a “conductive bond pad containing a copper layer” where the “copper layer contain[s] a copper oxide layer thereon” and a “titanium-aluminum-copper-nitrogen layer formed as part of [the] copper layer and from a portion of at least an upper surface of [the] copper layer.” Appellant respectfully submits that the cited combination fails to disclose, teach or suggest the invention of claim 79.

Edelstein relates to a process for fabricating a corrosion-resistant conductive pad on a substrate. Edelstein, Abstract. The conductive pad is formed of an alloy derived from a metal layer being annealed with a second metal layer. Edelstein, col. 4, lines 33 – 60. As stated by the Examiner, Edelstein discloses an aluminum-copper alloy. November 3, 2006 Final Rejection, page 4.

Harada relates to adding small amounts of one of many possible materials, including copper and titanium, to an aluminum alloy film in order to enhance the resistance to electromigration. Harada, col. 6, lines 54 – 61.

Mahulikar relates to a composite copper alloy having a copper alloy core and a modified surface layer containing a nitride or carbide film. Mahulikar, Abstract. This surface layer acts as a barrier on the surface of an iron or nickel-based alloy, thereby providing improved tribological (i.e., friction and wear) and mechanical properties.

- a. One skilled in the art would not have been motivated to combine Edelstein, Harada and Mahulikar.

Appellant respectfully submits that Edelstein, Harada and Mahulikar are not properly combinable. There would have been no motivation to combine the references for the purpose of teaching or suggesting a titanium-aluminum-copper-nitrogen layer absent the impermissible use of hindsight using the claims of the present application as a roadmap. The mere fact that references can be combined or modified is not sufficient to establish *prima facie* obviousness, the prior art must also suggest the desirability of the combination, which is not present here. M.P.E.P. § 2143.01 (citing In re Mills, 916 F.2d 680, 16 U.S.P.Q.2d 1430 (Fed. Cir. 1990)).

The Final Rejection has not provided a sufficient motivation to combine these references. Instead, the Final Rejection merely states “it would have been obvious ... to have the titanium ... to enhance the resistance to electromigration” and “it would have been obvious ... to have the nitrogen ... to improve tribological and mechanical properties while maintaining useful electrical

conductivity.” November 3, 2006 Final Rejection, pages 4 – 5. Appellant respectfully disagrees that this sets forth a motivation to combine the three cited references to arrive at the claimed invention.

Harada relates to the improvement of an aluminum film by adding elements to the aluminum. The present application states that using a copper layer to form the bond pad is itself an improvement over using an aluminum layer; therefore, one skilled in the art would not be motivated to combine a reference that teaches merely improving aluminum to improve a copper bond pad since the copper is already better than aluminum. Also, such a combination would not arrive at the claimed invention. Moreover, neither Harada nor Mahulikar provides any motivation to combine their teachings with bonding pad references in order to reduce oxidation of copper. Accordingly, Appellant respectfully submits that one skilled in the art would not have been motivated to combine the references in the manner suggested by the Office Action.

In light of the above arguments, Appellant respectfully submits that the independent claim 79 is not obvious in view of Edelstein, Harada and Mahulikar and the 35 U.S.C. § 103(a) rejection should be overturned.

2. Claims 80, 82 and 83 are not obvious in view of Edelstein in view of Harada and further in view of Mahulikar.

Dependent claims 80, 82 and 83 contain all of the limitations of independent claim 79 and are allowable along with claim 79, for at least all of the reasons discussed above. In light of the above arguments, Appellant respectfully submits that dependent claims 80, 82 and 83 are not obvious in view of the Edelstein, Harada and Mahulikar combination and the 35 U.S.C. § 103(a) rejection should be overturned.

VIII. CONCLUSION

For each of the foregoing reasons, Appellant respectfully submits that the claimed invention is not obvious in view of the cited prior art, and reversal of each of the final grounds of rejection is respectfully solicited.

IX. CLAIMS

A copy of the claims involved in the present appeal is attached hereto as Appendix A. As indicated above, the claims in Appendix A include the amendments filed by Appellant on August 21, 2006.

Dated: June 11, 2007

Respectfully submitted,

By 

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APPENDIX A – CLAIMS APPENDIX

Claims Involved in the Appeal of Application Serial No. 10/656,182

Claims 1-73. (Canceled)

74. (Previously presented) A copper bond pad for a semiconductor device, said bond pad comprising:

a dielectric layer formed over a substrate of said semiconductor device;

a barrier layer formed over said dielectric layer;

a copper layer formed over said barrier layer, said copper layer having titanium implanted within and near only an upper surface of said copper layer, said copper layer being primarily copper and having a thickness of about 500 Angstroms to about 20,000 Angstroms; and

an insulating layer over said copper layer,

wherein said implanted titanium acts to reduce formation of copper oxide on said copper layer.

75. (Previously presented) The copper bond pad of claim 74, wherein said titanium implanted within said upper surface of said copper layer has a thickness of about 50 Angstroms to about 200 Angstroms.

76. (Previously presented) The copper bond pad of claim 74 further comprising a passivation layer formed in contact with said copper layer, wherein said passivation layer is formed of a material selected from the group consisting of silicon oxide, oxynitride, silicon nitride, borophosphosilicate glass and polyimide.

77. (Previously presented) The copper bond pad of claim 76 further comprising a via formed in said insulating layer and said passivation layer, said via exposing a portion of said copper layer and defining a bond pad area.

78. (Previously presented) The copper bond pad of claim 74, wherein said dielectric layer is formed of a material selected from the group consisting of phosphosilicate glass, borophosphosilicate glass, silicon oxide, silicon nitride, and silicon oxynitride.

79. (Previously presented) An interconnect structure for a semiconductor die, said interconnect structure comprising:

a conductive bond pad containing a copper layer, said copper layer containing a copper oxide layer thereon; and

a titanium-aluminum-copper-nitrogen layer formed as part of said copper layer and from a portion of at least an upper surface of said copper layer.

80. (Previously presented) The interconnect structure of claim 79, wherein said copper layer is elemental copper.

Claim 81. (Canceled)

82. (Previously presented) The interconnect structure of claim 79, wherein said copper oxide layer has a thickness not greater than 300 Angstroms.

83. (Previously presented) The interconnect structure of claim 79 further comprising an electrical conductor bonded to said titanium-aluminum-copper-nitrogen layer.

APPENDIX B – EVIDENCE APPENDIX

A copy of evidence entered by or relied upon by the Examiner that is relevant to this appeal is attached hereto. Exhibits 1 and 3 were first entered by the Examiner in the Office Action mailed May 19, 2006. Exhibits 2 and 4 were first entered by the examiner in the Office Action mailed November 3, 2006. Exhibits 5 and 6 were first entered by the examiner in the Office Action mailed July 14, 2005.

Exhibit 1: U.S. Patent No. 6,424,036 to Okada

Exhibit 2: U.S. Patent No. 6,479,389 to Tsai et al.

Exhibit 3: U.S. Patent No. 5,661,082 to Hsu et al.

Exhibit 4: U.S. Patent No. 6,457,234 to Edelstein et al.

Exhibit 5: U.S. Patent No. 5,565,378 to Harada et al.

Exhibit 6: U.S. Patent No. 5,320,689 to Mahulikar et al.

APPENDIX C – RELATED PROCEEDINGS APPENDIX

No related proceedings are referenced in II. above, hence copies of decisions in related proceedings are not provided.